Volume 29 February, 1943 *Number 2*

Lubrication

A Technical Publication Devoted to the Selection and Use of Lubricants

THIS ISSUE

Street Railway Lubrication

PUBLISHED BY
THE TEXAS COMPANY
TEXACO PETROLEUM PRODUCTS

TEXACO LUBRICANTS

for

ELECTRIC STREET RAILWAY

ROLLING STOCK

ARMATURE BEARINGS, AXLE BEARINGS, CAR JOURNALS, WASTE SATURATION	Texaco Electric Car Oil (Summer or Winter), or Texaco Texayce Oil
BALL AND ROLLER BEARINGS	Texaco Marfak No. 2 H.D. or Texaco Starfak Grease M or H
COMPRESSORS (Car)	Texaco Electric Railway Compressor Oil (Summer or Winter)
GEARS AND PINIONS (According to Locality)	Texaco Crater No. 2 or No. 5 for Summer or Texaco Crater No. 1 or No. 2 for Winter
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(Continued on Inside Back Cover)

LUBRICATION

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Published by

The Texas Company, 135 East 42nd Street, New York City

Vol. XXIX February, 1943 No. 2

Change of Address: In reporting change of address kindly give both old and new addresses.

Street Railway Lubrication

STREET RAILWAY transportation has had its problems intensified during the past year due to the necessity for gasoline and rubber conservation. So, the trolley car is back again, as a partner to the motor bus, in serving the commuter, the warplant worker, the school-child and the housewife.

But the modern trolley car is as different from its predecessor which supplanted the horse-car as the streamline bus is from the "jitney". Today, the P.C.C.* car and trolley coach, for example, symbolize speed, comfort and reliability.

The modern street railway car is still designed as a unit propulsion vehicle powered from a central station by an overhead power line or from below street level, by a suitable power take-off. Consequently, it still requires an assembly of controls, electric motors, power transmission gears, and journal boxes to convert this power into motion at the wheels. It is interesting to study a lubrication chart of the moving parts of the P.C.C. car as shown in Figure 4. The design of the respective parts differs to some extent from the design of the conventional car, also different lubricants are required for some parts yet there is considerable over-all similarity.

Like the body of the modern electric railway car and trolley coach these parts have been streamlined though for a different purpose than appearance and reduced air-resistance. In considering motor, gear box and axle assemblies, the designing engineer has considered chiefly a type of construction which will afford better protection of the bearings and gears. By so doing he has provided more effectually for the protection of their lubricants. As a result, greater durability is expected of these products. The petroleum industry has cooperated by intensive research which has assured of this durability.

It is interesting to note just what is meant by durability. As inferred, it denotes resistance to breakdown which to the chemist means resistance to oxidation. It has been practicable to build this characteristic into the modern street railway motor bearing or gear lubricant because the parts to be lubricated are sealed against ready entry of oxidizing influences, i.e., air, dirt and water. This is a most important factor in the interest of reduced maintenance costs. As it contributes to lengthening the life of the component parts the costs per car mile for operation, maintenance and lubrication also have been reduced.

TYPES OF LUBRICANTS

Street Railway Lubricants can be grouped in six classifications according to the type of machinery they must serve; i.e.,

Car Oils
Compressor Oils
Gear Lubricants (Spur gears, herringbone or Hypoid Type)
Spring Lubricants
Ball and Roller Bearing Lubricants
Universal Drive Lubricants

These products all must be refined as well as the limits of their respective classifications will permit, for the nature of the operating conditions may preclude effective lubrication. Cars operate at high speeds, through areas where

* Development of the P.C.C. car was sponsored by The Conference Committee of Presidents of a number of the leading street railway companies in the U. S. in 1932. The resultant car was named the Presidents' Conference Committee car.

considerable dust prevails, exposed to water and snow in bad weather. Water wash and windage are factors which may cause serious contamination of motor bearing and gear lubricants if the housings are not tight.

A fairly wide temperature range also may prevail due to climatic conditions, and frictional or electrically generated heat. Overloading is a frequent cause of overheating. Low voltage due to poor track bonding or line transmission conditions is also a contributing factor. Poor track may be caused by conditions which may not permit of correction.

CAR OILS

Car Oils are the volume lubricants on any electric railway where waste-packed motor and axle bearings prevail. There are still many of the old style cars in service which include this type of bearing, and more will probably be put in operation to meet transportation demands.

The car oil of today, however, is a far more dependable lubricant than it was in the "Twenties." It has benefited by advances in petroleum refinery technology, also by the high quality crudes which are today obtainable from many of the more recently developed oil fields.

TABLE NO. I

CAUSES OF FAULTY LUBRICATION OF WASTE-PACKED BEARINGS

Condition	*Cause*	*Effect*
Shifting of bearing in housing.	A sheared dowel or key.	Prevents window in bearing from registering with window in waste well, thus cutting off the oil feed.
A distorted bearing.	Bearing fitted too tightly in housing.	Causes motor to turn sluggishly and uneven bearing wear. Causes motor to become overheated.
Poor fit between bearing and housing.	Loose or stretched housing bolts on split type motors. Improper use of shims.	Permits oil to leak outside the bearing.
Misalignment in reboring bearings.	Careless handling of boring bar.	Uneven bearing wear. Excessive overheating.
Insufficient end play.	Faulty adjustment.	End plate wear.
Water and dirt.	Leakage, insufficient attention to draining.	Water can wash out oil and cause waste glazing. Dirt scores the bearings.
Armature strikes pole pieces.	Worn bearings.	Damage to windings. Power loss. Excessive wear of contact surfaces.

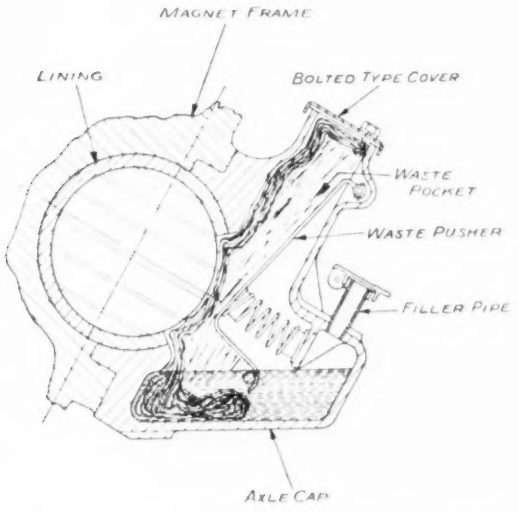
Motor speeds on the P.C.C. car, the trolley coach and other modern equipment became a factor as they are considerably higher than the speeds on the older type of cars. The maximum safe motor speed on the former ranges from 4500 to 5000 r.p.m., as compared with 2400 to 2800 r.p.m., on the older, axle-hung street car motors. The modern motor, however, is equipped with ball or roller bearings, which simplifies the problem of lubrication and eliminates the need for as frequent attention as prevails where a waste-packed bearing is involved.

This has encouraged greater care on the part of the railway maintenance executive in selecting waste, standardizing methods of waste saturation and packing, and oil and waste reclamation procedures.

Type of Oil

Straight mineral oils are most suitable for lubricating waste-packed journals, and armature and axle bearings. The latter form part of the motor suspension, so they contribute towards maintaining constant distance between the center-lines of the armature and

axle. Any material change in bearing clearance would lead to misalignment and cause future wear quite rapidly. Lubrication of these bearings, therefore, must be positive, and assured by the suitability of the car oil and constant contact with the waste. Straight mineral oils pre-



Courtesy of General Electric Company

Fig. 1—An axle cap of G.E. design with waste pusher. This is a large oil capacity type.

serve the capillarity of the latter most effectually, reduce the possibility of glazing of the contact surface, and resist emulsification when properly refined.

The rate of oil feed is controlled largely by the viscosity of the oil, provided the waste is of the proper resiliency and has been carefully saturated and packed. Accordingly, the higher the viscosity the lower will be the rate of oil feed.

As the temperature, in turn, affects the viscosity it is important to consider the operating range when selecting the oil. Research has proved that a dividing line at 40 degrees Fahr., can be adopted. Above this temperature conventional summer grade car oils can be used of a viscosity, around 100 seconds Saybolt Universal at 210 degrees Fahr. Below 40 degrees Fahr. a winter grade oil is advisable, ranging around 50 seconds Saybolt at 210 degrees Fahr. Low pour test is an added requirement which should be stipulated.

Summer car oils are refined to have about the same viscosity at average summer temperatures as winter car oils have at average winter temperatures. As these oils are produced from the same basic stocks, they blend perfectly; this permits of gradual change in the viscosity according to temperature changes at the turn of the seasons.

Bearing Wear and Faulty Lubrication

Mindful of the fact that bearing wear occurs at a rate which is approximately inversely proportional to the quantity of oil applied to a waste-packed bearing, the designers have perfected very effective types of bearing seals to prevent entry of abrasive foreign matter and leakage of oil. Wheel wash can become one of the most usual causes of oil contamination if the seals are loose or the dust caps or waste box covers do not fit tightly.

Axle bearing wear is not as harmful as armature bearing wear because the detrimental effect of excessive clearances are not as serious. Even so, excessive axle bearing clearances cause shocks and unnecessary strains in the motor frame, the axle caps and axle cap bolts; and change the center-to-center clearances between the axle and motor shaft. The resultant spreading of the gears causes excessive wear of the gear and pinion teeth due to excessive rubbing contact. This will begin to take place if the clearance exceeds one-eighth of an inch.

The Oil Level Must be Properly Maintained

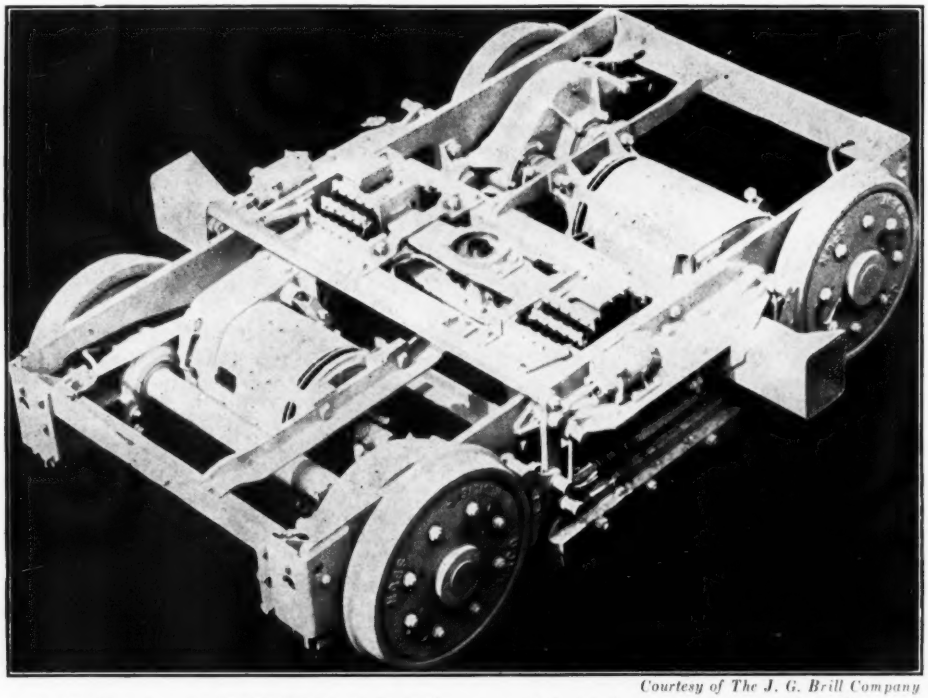
Oil lubricated sleeve-type bearings should be gaged regularly for oil level in the reservoirs, and only the amount of oil necessary to bring the level to the proper height should be added.

In the railway-type motor, should gaging show that very little oil has been fed since the last inspection, there is good reason to believe that the hole at the bottom between the two wells is plugged, and it should be cleaned before oil is added. By keeping this hole open, all oil can be added through the oil well rather than at the top of the waste. Some dust is bound to get into the waste, and adding the oil on top washes the dust down to the bearing. If evidence of water is found in the waste, the latter should be removed and the bearing packed with new waste. Water-soaked waste is less able to hold and deliver oil to the shaft surface.

GEARS AND PINIONS

The care and judgment used in the selection and application of electric traction gear lubricants has a definite effect upon the operating and maintenance expense. As a general rule the gears and pinions are subjected to unusually hard wear, owing to the sudden shock loads which are imposed when starting the car, or when the motors change from series to parallel. This is especially true where rapid acceleration is desired. Unless the teeth are protected by a cushioning film of lubricant, the resultant wear will shorten the period of usefulness, and make expensive replacements necessary. Worn gear teeth also have a detri-

mental effect on the life of the armature bearings, especially on the gear side. In turn, this may frequently result in serious damage to the armature and field windings. The designers have anticipated this possibility by providing adequate means for enclosing and protecting



Courtesy of The J. G. Brill Company

Fig. 2—Top view of a Brill 97-ER-1 truck for Brilliner cars. Note details of gear drive assembly in Fig. 3.

the gears against entry of abrasive or non-lubricating foreign matter. So the problem in service resolves itself into the selection of the proper lubricant and its application.

Nature of the Lubricant

To function most dependably, a gear lubricant

1. Should not harden nor contain any residual matter that is of a non-lubricating character.
2. It should possess marked adhesive properties in order not to drip or flow excessively under abnormal temperature rise nor be thrown off by the action of centrifugal force, or rubbed off under operation.

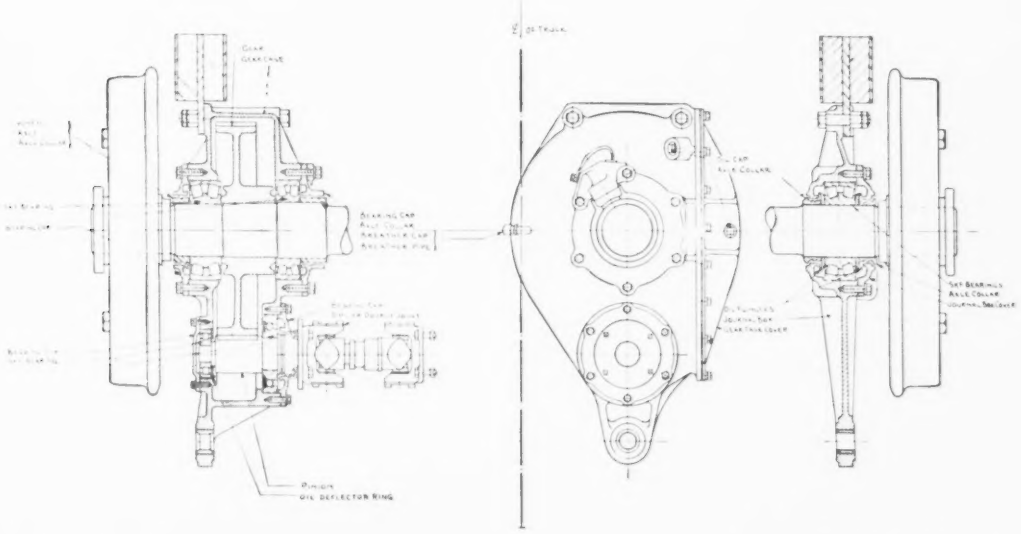
   It should not be so tacky, however, as to increase the rolling resistance; undue drag consumes power to an unwarranted excess.
3. It should be of sufficient body to withstand the excessively high pressure at the point of contact of the teeth, and thereby prevent actual metal-to-metal friction occurring, whatever the season of the year.
4. It should be entirely free from acids or alkalies which would have a tendency to cause a certain amount of pitting on the highly polished tooth surfaces.
5. It should resist heat and be non-reactive to water, acid or alkali.
6. It should be able to free itself of dirt and particles of worn metal, which otherwise would give it an abrasive effect.
7. It should be relatively easy to apply.
8. It should retain its lubricating ability during the periods between re-lubrication.
9. It should cushion operating noises as far as possible. "Sound effects" in transportation are a detriment to nerves.

A lubricant that will meet all of these requirements without a doubt will increase the life of gearing to a considerable extent and reduce the labor charges and other costs incident to the maintenance of electric traction equipment.

Factors Which Control Selection

Electric transit gear lubricants are selected according to the maximum seasonal changes in temperature, the nature of the roadbed or highway, and the length of sustained runs. It is necessary that uniform results be obtained throughout the year from such lubricants. In order to meet this requirement it may be necessary, in certain localities of widely differing maximum and minimum temperatures, to use special grades of gear lubricants according to

the season and temperature of operation, so that the viscosity of the lubricant in the gear case will be approximately the same throughout the year. Otherwise at some time of the year the lubricant might be too thin for the service, resulting in possible leakage from the gear case and ring gear. The greater sliding action which occurs between the teeth of a set of hypoid gears creates a wiping effect which, combined with high tooth pressure, may rupture the lubricating film unless the lubricant is manufactured to develop high load-carrying capacity. Hence



Courtesy of The J. G. Brill Company

Fig. 3—Gear drive assembly for Brilliner electric trolley truck. Note construction features pertaining to bearings and sealing.

or excessive splashing. At other times the lubricant might be so heavy as to settle in the bottom of the case in a semi-solid mass, the gears just cutting a channel through it, and running practically dry meanwhile.

For normal summer service a gear lubricant for spur or bevel gears should have an approximate viscosity of 2000 to 5000 seconds Saybolt Universal at 210 degrees Fahr. For cold weather operations the viscosity should be decreased to approximately 1000 to 2000 seconds Saybolt Universal at 210 degrees Fahr.

Hypoid Gearing

The principle of the hypoid gear is employed in the design of the gear assembly on the P.C.C. car and in some types of trolley buses. This trend in design developed when lower vehicle bodies were desired to attain better road stability, and motor speeds were increased to improve car pick-up speed. Greater tooth pressures resulted but fortunately these have been met by the perfection of lubricants of very high film strength which can effectively withstand these pressures.

In contrast with conventional gear tooth design where motion is largely of a rolling nature, the hypoid develops a longitudinal sliding motion between the teeth of the pinion the development of those extreme pressure (E.P.) and hypoid lubricants which have become so well known to the motorist; and the industrial E.P. lubricants for gears in industry where load conditions comparable to the hypoid are involved.

Means of Lubrication

Hypoid gears in electric transit service are bath-lubricated. Accordingly they are contained in an oil-tight case which at the same time is sealed to prevent entry of contaminating foreign matter. The gear case is kept filled to a pre-determined level, and the manufacturers recommend that the lubricant be drained and the case refilled every 35,000 miles. This same lubricant serves the inboard axle bearings. (See A and B on the lubrication chart, Fig. 4.)

The protective ability of the lubricant is most important in a hypoid installation due to the very low maintenance tolerance which is required, viz., the maximum allowable wear is .0020 of an inch. Accordingly, the lubricant which will enable the most miles of operation before this maximum is reached is the most desirable.

The load on the lubricant is also affected by braking. On the P.C.C. car a good share of the

braking effect is developed through the hypoid gearing.

OTHER EQUIPMENT

Equally as careful attention should be paid to the lubrication of air compressors, door engines, motorman's valves, air brake piston cylinders, foot valves, circuit breaker cylinders, brake hangers, brake adjusting rods and other parts of brake rigging, truck center bearings, trolley wheels and trolley pole bases.

Air Compressors

These units furnish the braking power. They are equally as important as the motive power equipment. In consequence, regular inspection and careful lubrication are required in the interest of safety. The oil-filling elbow of a motor-driven compressor is usually placed low on the side of the crank case near the motor. Its location is such that it serves also as an oil gauge. The normal oil level should not exceed one quarter of an inch below the top of the filling elbow. Whenever the level has dropped to three-eighths of an inch below the top, make-up oil should be added. Under ordinary conditions, additional oil will be required only once in several inspections.

The vent pipe is an important accessory on the compressor. If the vent pipe is clogged, oil from the armature bearings cannot return to the chamber as it should, but will be discharged through the safety drain and wasted. This is indicated by oil around the vent pipe. Every effort, therefore, should be made to keep the vent pipe open.

In removing a vent pipe a socket wrench should be used in preference to any other type of wrench. When the pipe is replaced, care should be taken to see that the threads are well shellaced. The condition of the vent pipe can be determined by placing one's hand against it. If no indication of air issues therefrom, the pipe is probably clogged with dirt; but if light puffs of air are felt, it is clear. If a compressor is found with a vent pipe clogged, a record should be kept thereof so that it can be followed up on the subsequent inspection and the condition corrected. The pipe plug at the bottom of the settling well should be removed at least once a year and any sediment that may have collected drawn off.

The following precautions as to the care and operation of air compressors are suggested in order to obtain satisfactory lubrication, viz.:-

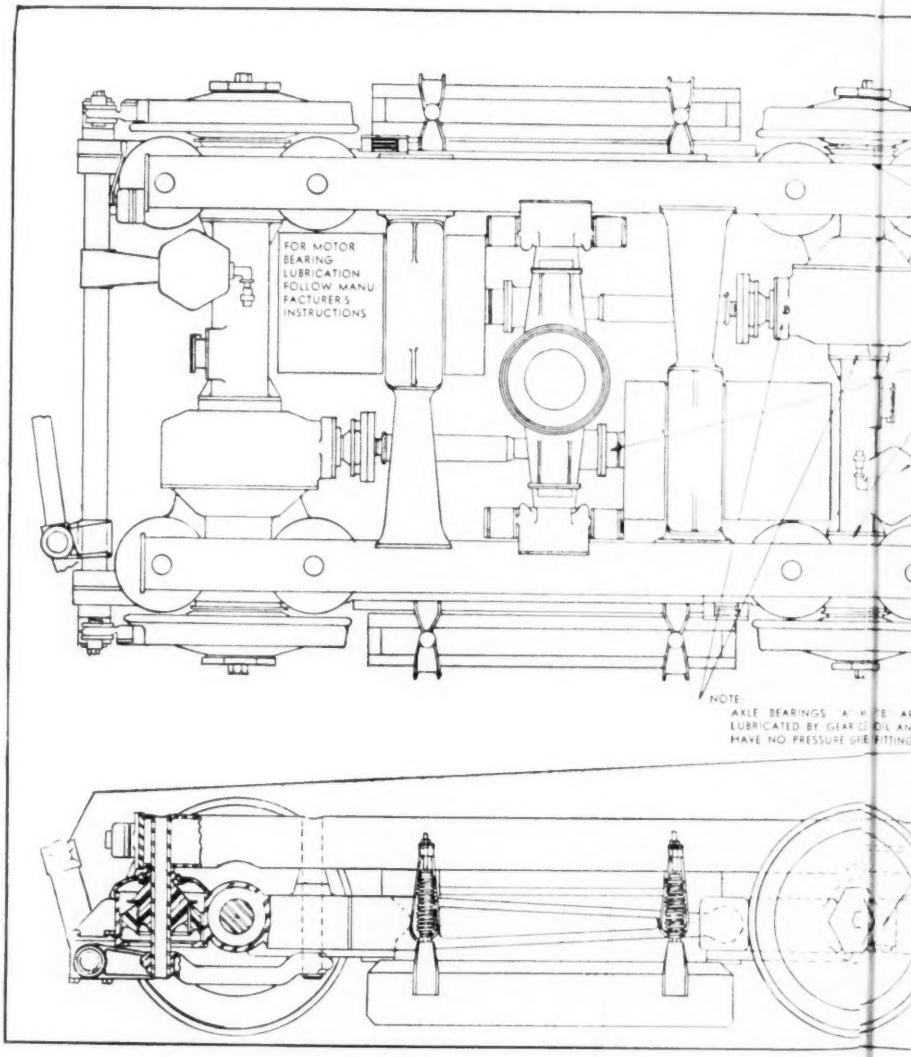
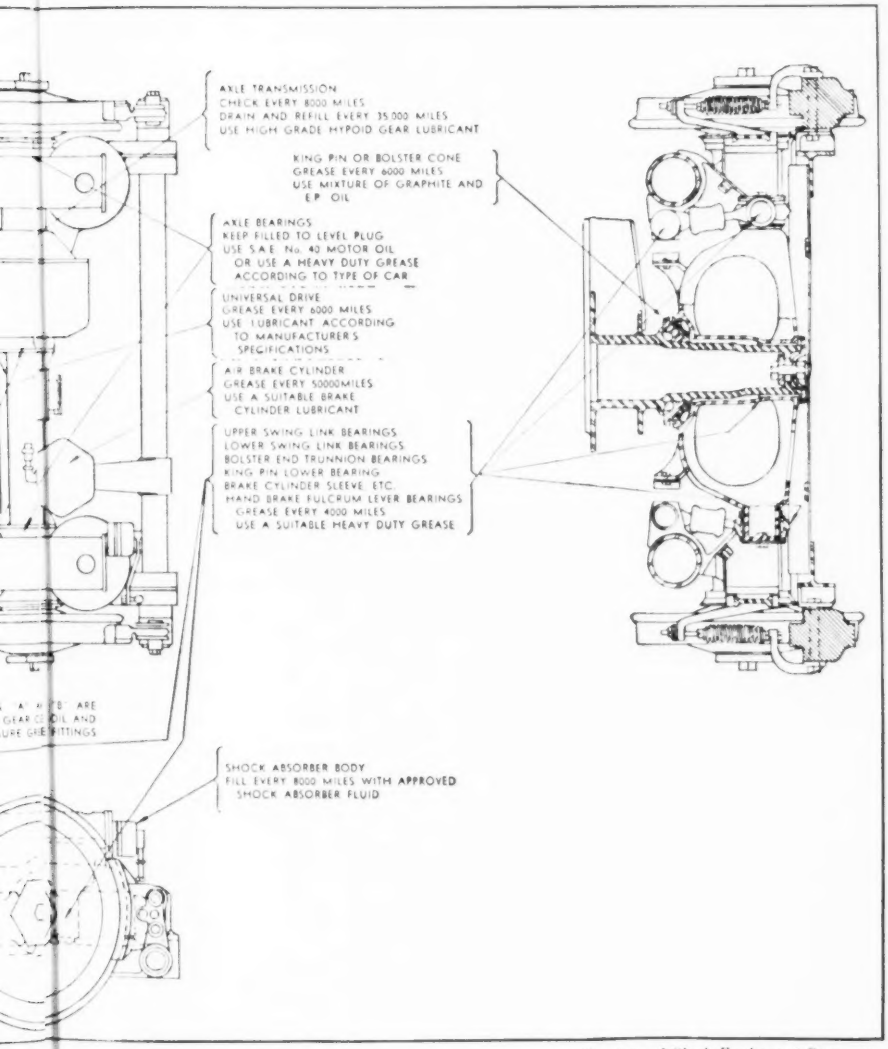


Fig. 4—Lubrication chart for P.C.C. trucks built after Jan. 1, 1940.

1. Keep oil passages clear to insure of proper oil circulation.
2. Renew oil periodically; at least each time compressor is completely overhauled.
3. Keep the outside of the compressor clean to enable better radiation and cooling.



Courtesy of Clark Equipment Company

4. Keep the suction air strainers clean to prevent entry of dirt into the oil and to insure an unrestricted flow of air.

Door Engines

Door engines open and close the doors of the street car and trolley bus. They are designed to function automatically under control of the operator. The trend in the modern design has been toward reduction in weight, also simplification of the working parts. To some extent this has led to simplified lubrication.

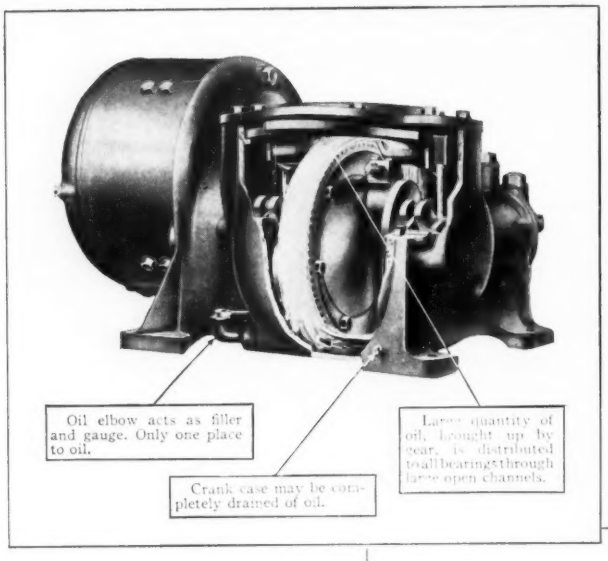
Grease Lubricated Models

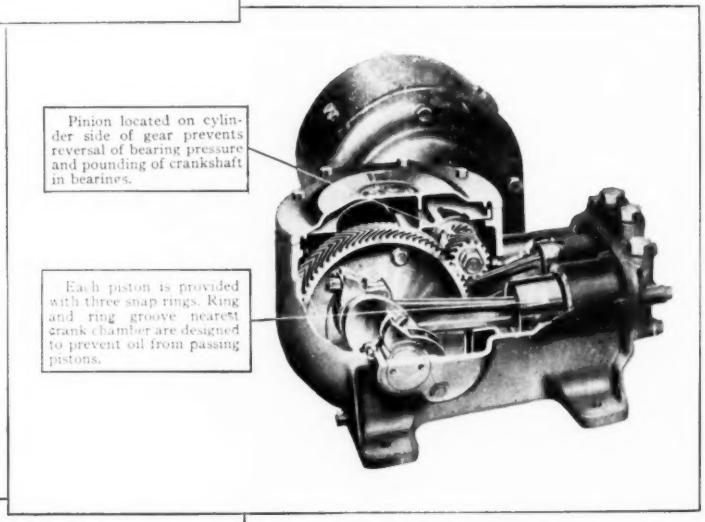
Older models of door engines were designed to be lubricated by a semi-fluid grease placed in the gear chamber of the engine. Many of these devices are still in service. This grease works past the piston cups and into the free exhaust ports in the cylinder walls. From there the grease works through the air passages and valve to the gear chamber. In this way a sufficient quantity of lubricant is always reaching the valve mechanism to keep it functioning properly.

One charge of grease in such a door engine will last about one year, after which it will probably be found that a small amount of make-up should be added. At the end of the second year or when the engine is removed from the car for overhaul, it should be thoroughly cleaned, new piston cups installed, and a new charge of grease put in the gear chamber.

At the same time the air strainer should be cleaned thoroughly and the pipes blown out before replacing the engine. The quantity of lubricant required varies with engines of different size, but, ordinarily, about one pound will suffice. At monthly intervals, however, a small quantity of electric railway compressor oil should be put in the slide block cavity of the door slide.

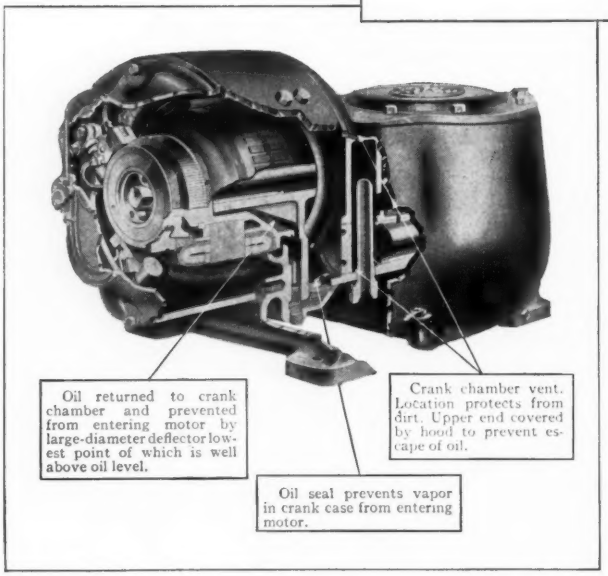
Where door engines are located in a remote position or are set so that mechanical control is not convenient, a pneumatic valve puller, or auxiliary cylinder can be installed. The cylinder walls of this device should likewise be lubricated with electric railway compressor oil through the forward supporting cap screw to a





Courtesy of General Electric Company

Fig. 5—Cutaway views of a G.E. electric railway air compressor showing details of the self-contained lubricating system.



felt wiping pad attached to the piston.

The Modern Design

The cylinder walls of the modern trolley door engines are lubricated with a straight mineral oil of around 300 seconds Saybolt Universal Viscosity at 100 degrees Fahr. The oil is applied to felt lubricating rings (See Fig. 6) which are attached to both pistons. These lubricating rings should be saturated with oil, at intervals of from three to four months.

The lubricating ring of the smaller piston is saturated by applying oil with an oil can to the four oil holes provided in the outermost part of the piston, at the smaller end of the door engine. By moving the piston outward, these oil holes become accessible.

To saturate the lubricating ring of the larger piston, the screw in the end of the tube fitting at the center section of the door engine, is removed. Then, one ounce (or two tablespoonfuls) of oil is poured into the screw hole.

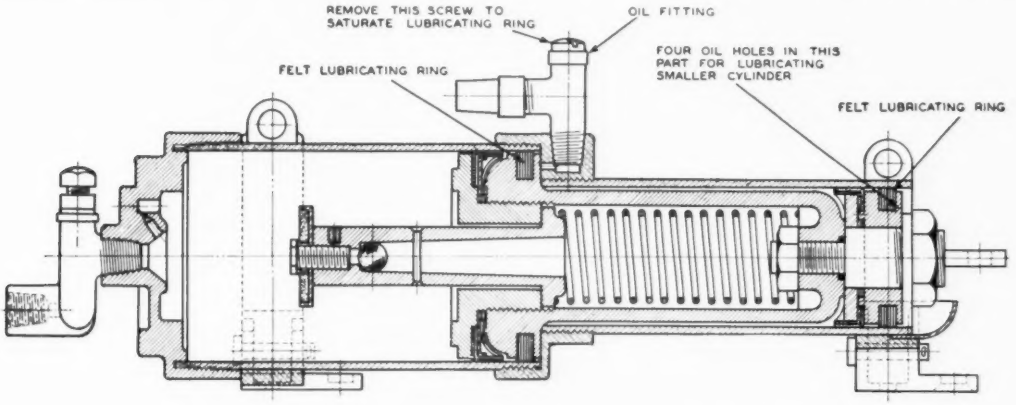
If the oil does not flow freely into the door engine, move the piston slowly from its extreme outward position, which will draw the oil into the engine. Then, replace the screw, turn on the air and operate the engine a few times, after which the piston should be turned half way around to insure proper saturation of the lubricating rings.

When a door engine is removed from a car for overhauling, it is usually taken to a bench, dismantled, thoroughly cleaned, new piston cups installed and the felt lubricating rings are saturated with oil.

At monthly intervals, the pins in the terminal connections should be lubricated with graphite grease.

Motorman's Valves

For the lubrication of motorman's valves, air brake cylinders, foot valves and circuit breaker cylinders, the same grease as used for grease lubricated door engines should be applied when these other devices are on the bench



Courtesy of National Pneumatic Company

Fig. 6—Structural details of a differential door engine of the oil lubricated type.

to be overhauled. In addition, at the regular "light inspection" periods the brake cylinders should be lubricated with electric railway compressor oil.

Brake Castings

On trucks equipped with half ball hangers and brake adjusting rods, modern practice is to provide for pressure grease lubrication. The fittings are installed at the center of the half ball brake hanger casting so that the grease will flow to each hanger. The fittings on the brake adjusting rods are installed over the threaded part of the castings. Pressure grease lubrication assures that the lubricant will be distributed more easily and positively to the points at which it is required. This extends the life of these castings and results in a considerable decrease in truck noises. The lubricant, of course, should be a high quality soda-soap grease compounded with a heavy bodied mineral oil to impart shock-absorbing ability.

Center Bearings

Lubrication of truck and body center bearings has also been perfected on the modern trolley, an oil retaining center bearing being used on most modern car trucks. This involves a brass wearing ring constantly immersed in an oil bath, with felt rings to keep out dust between the top and bottom halves of the bearing. The result is smooth and steady riding and reduced wheel flange and track wear on curves.

In oil-retaining center bearing is refillable from inside the car through a pipe in the body bolster using a seasonal grade of car oil.

Trolley Wheels and Bases

The slide under the trolley fork on trolley wheels should be lubricated frequently with the same grade of oil as is used in air compressors. The bushing of the trolley wheel should also use this product if the bushing is solid; or, if it is hollow, best results will be obtained by pressure grease lubrication.

In the modern trolley base, two tapered roller bearings working in renewable tapered bearing cups support the base and give free lateral trolley pole movement. Perfect enclosure, with unusual accessibility are advantages of this design. The bearings are protected against dirt and weather by the turret housing, which fits closely over the stem casting. They are adjustable without removal from the housing. Ample lubrication over long periods is provided by packing the bearing housings with a medium bodied soda-soap grease. A leather cup washer below the bottom bearing acts as a seal and prevents leakage of grease from below the bearing. A removable pipe enables easy renewal of the lubricant by means of a grease gun. Thus the need for frequent lubrication, or even inspection, is very largely eliminated.

Electric Railway Ball and Roller Bearings

Roller bearings have been widely adopted for the axle bearings of the more modern cars, and the wheel bearings of the trolley coach or trackless trolley. In addition, roller bearings are part of the modern trolley base assembly. Ball or roller bearings also are used on traction

motors. On the P.C.C. car the gear case bearings may be lubricated by the gear case oils; elsewhere provision is made for grease lubrication.

Traction motor or axle bearings can show a life of from 50,000 to 250,000 miles according to the extent to which they are protected; i.e.,

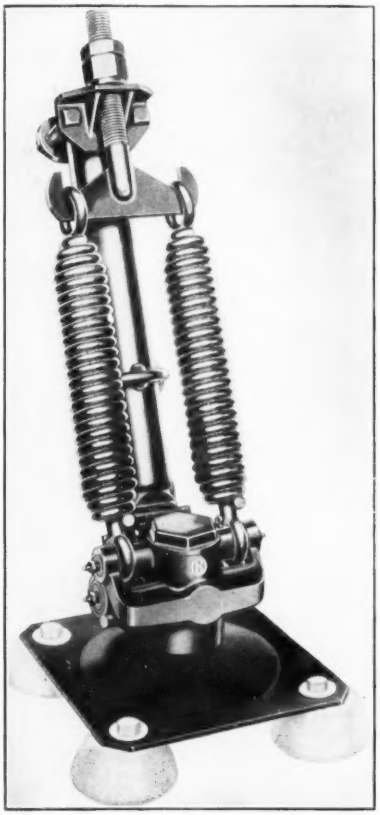
Inspected regularly.

Enclosed in tight housings to prevent entry of water or dirt, or loss of lubricant.

Re-lubricated *with care* at six-month intervals or longer, according to experience.

Drained, flushed and relubricated when the bus or car is in for general overhaul.

During this period they will be subjected to comparatively high temperature, 200 degrees Fahr., being a probable maximum. At the same time the speed of the armature may run as high as 5000 r.p.m. Axle roller bearings, however, are ventilated better so their temperatures usually are lower; likewise the speeds range considerably lower according to the car speed.

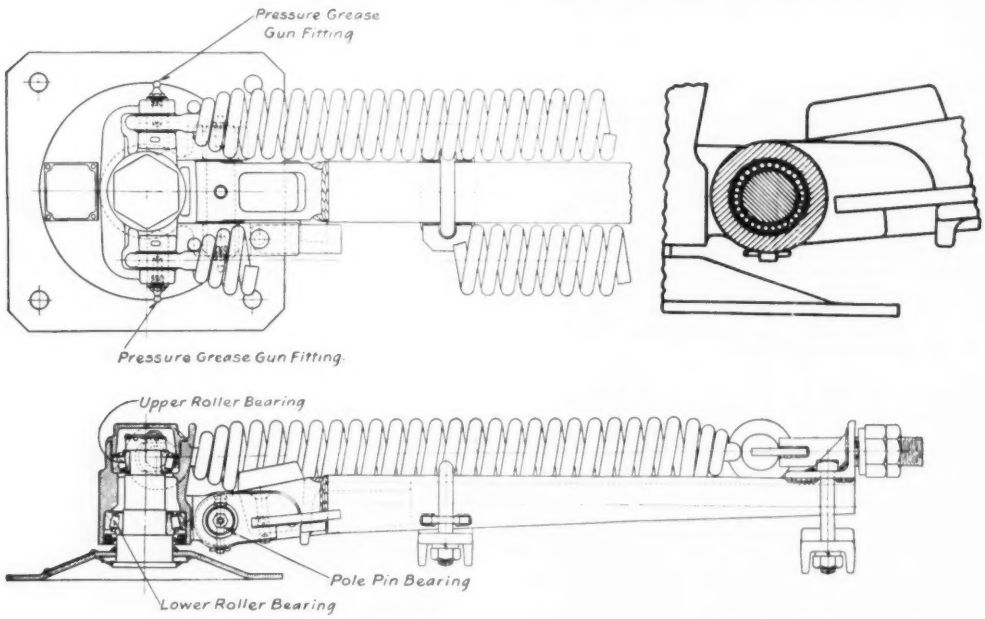


Selecting Greases

To obtain the maximum mileage from any grease lubricated ball or roller bearing requires that the grease be specially prepared for the service involved. Resistance to oxidation and breakdown are most important characteristics as all or part of the original charge of grease may be in service for several months according to the way the cars are run.

It is not sufficient to advise that the grease be of a certain base and texture, and free from non-lubricating fillers. Sometimes physical characteristics are quite misleading. They can change markedly with change in temperature or when the grease becomes oxidized.

Accordingly, the procedure in manufacture should be to anticipate the operating conditions by devising laboratory test equipment wherein the behavior of any prospective grease can be observed over



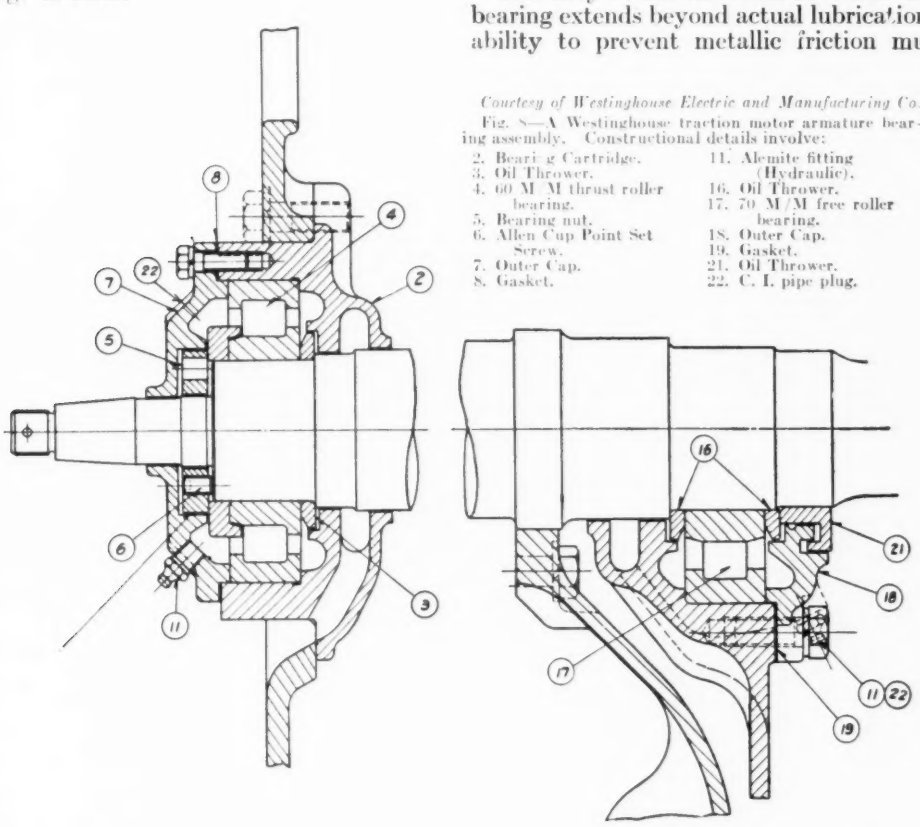
Courtesy of Ohio Brass Company

Fig. 7—Elevation and detail views of the O-B form 11-T trolley base for trolley coaches, showing location of anti-friction bearings, the pole pin bearing details and the pressure grease gun fittings.

the expected range of temperatures, on bearings run at motor or journal speeds. In this way the grease chemists study and record all developments which may affect the lubricating ability of the grease in question.

For example:

Starting and running torques.
Grease expansion.
Grease leakage.
Aeration,—which may cause expansion or leakage.
Change in texture.
Change in color.



Courtesy of Westinghouse Electric and Manufacturing Co.

Fig. 8—A Westinghouse traction motor armature bearing assembly. Constructional details involve:

2. Bearing Cartridge.
3. Oil Thrower.
4. 60 M/M thrust roller bearing.
5. Bearing nut.
6. Allen Cup Point Set Screw.
7. Outer Cap.
8. Gasket.
11. Alemite fitting (Hydraulic).
16. Oil Thrower.
17. 70 M/M free roller bearing.
18. Outer Cap.
19. Gasket.
21. Oil Thrower.
22. C. I. pipe plug.

Indications of oxidation or breakdown,—denoted by gummy texture at end of test, and
Indication of etching.

The durability of a grease is synonymous with its lubricating ability; any change in the physical or chemical nature which will affect this is objectionable. The physical nature of a ball or roller bearing grease is most apt to be affected by temperature or moisture; the chemical nature by oxidation of certain of its petroleum or fatty oil components.

Temperature affects the consistency inversely. In other words, the grease gets harder as the temperature goes down, and softens at higher temperatures. Within certain reasonable limits, this has comparatively little effect upon the lubricating value. To be sure, relubrication at low temperatures may be more difficult, some grease guns being unable to pump certain greases. Conversely, as the higher temperature limits are approached, leakage may develop, but this is not likely if the grease is specifically prepared for ball and roller bearings and the seals are effective.

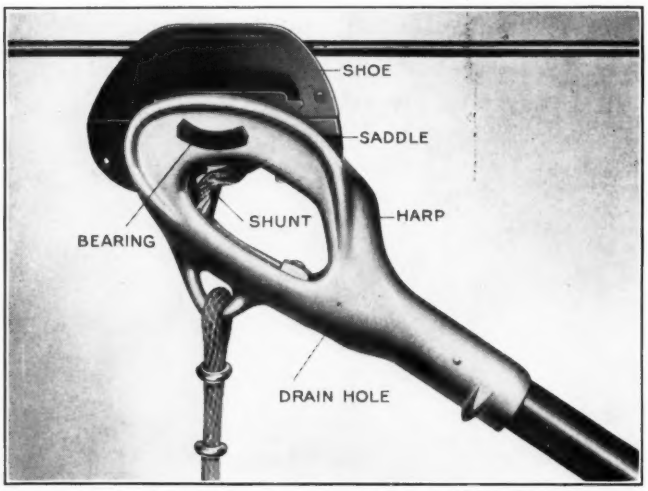
How the Lubricant Functions

The duty of the lubricant in a ball or roller bearing extends beyond actual lubrication. The ability to prevent metallic friction must be supplemented by the protective ability, whereby the lubrication film is such that corrosion is prevented, even under a wide variation in atmospheric conditions.

Essentially, rolling motion is involved, meaning that in a properly designed bearing which has not been subjected to abnormal wear, the possibility of sliding contact will be relatively negligible. Actual contact between metallic bearing surfaces of the balls or rollers and their cages or retainers is the principal cause of wear. To prevent this, a lubricating film is interposed; that is, a film of suitable thickness and body to keep the metallic surfaces apart in the face of the prevailing speed and pressure. In this

way fluid friction supplants solid friction to reduce the ultimate wear.

It is, of course, desirable to reduce frictional wear in any such bearing as much as possible. The occurrence of undue wear may lead to misalignment which, in a motor may cause the rotor shaft to pound in its bearings and the armature coils to come in contact with the pole pieces which may result in burnouts.



Courtesy of Ohio Brass Company

Fig. 9—The O-B type J-6 harp and shoe for use as a current collector on rail cars.

Lubrication is further protected if there is suitable provision in the bearing housing for complete cleaning or flushing when necessary. The frequency of such a procedure will be governed by the type of bearing and the service conditions to which it is exposed. An oil-lubricated bearing will automatically flush itself, foreign matter settling in the reservoir below the bearing. Not so for the grease lubricated bearing, as the grease holds contained foreign matter in suspension.

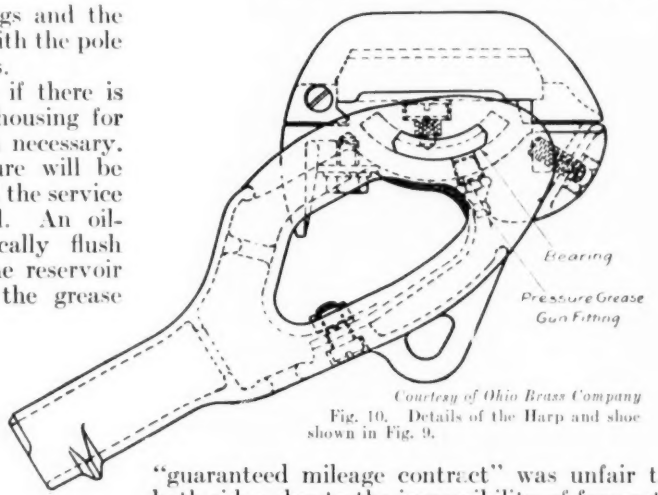
Sealing to prevent entry of foreign matter automatically protects both the bearing and its charge of lubricant. It is especially important to protect the ball or roller bearing, as churning of abrasive foreign matter with grease between moving parts which are precision-built to clearances of only a few ten-thousandths of an inch will cause serious damage to the bearing elements. For this reason, specialty greases for ball and roller bearings are prepared from carefully selected and filtered ingredients.

The seal should be so effective as to keep such lubricants in this high state of purity. Given a good grease and a good bearing seal, relubrication is necessary at very infrequent intervals, viz.:—Some operators recommend relubricating motor armature roller bearings every 30,000 miles, and ball bearing trolley bases every 10,000 miles.

CONCLUSION

In the lubrication of electric powered street railway transportation equipment, progress became a matter of method when car equipment designers planned for better protection of lubricants. When lubrication was purchased on a mileage basis the incentive to save was mainly the responsibility of the oil supplier. In those days the latter guaranteed to the railway that the cost of lubrication per thousand car miles would not exceed a specified figure.

Contracts of this nature often led to waste of lubricants. Also to high maintenance costs, for if the supplier had guessed too low, and subsequently insisted on economy, starved bearings resulted,—for usually oil economy was considered regardless of other conditions. Obviously the "guaranteed mileage contract" was unfair to both sides, due to the impossibility of forecasting costs of raw materials and labor a year or so in advance.



Courtesy of Ohio Brass Company

Fig. 10. Details of the Harp and shoe shown in Fig. 9.

The modern procedure of purchasing lubrication on a volume basis, and educating repair and maintenance personnel to the fact that lubrication is most effectual in protecting and prolonging the life of gears and bearings, is a far more satisfactory way to keep down repair costs. Today, with many replacement materials on a priority basis, familiarity with design, the means provided for lubrication, and the nature of the accepted lubricants is more important than ever.

Printed in U. S. A. by
EDGAR C. RUWE CO., INC.
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TEXACO LUBRICANTS
for
ELECTRIC STREET RAILWAY

ROLLING STOCK

(Continued from Inside Front Cover)

TROLLEY BASES	
Plain Bearings	Texaco Electric Railway Compressor Oil (Summer or Winter)
Ball Bearings	Texaco Starfak Grease L or M
TROLLEY WHEELS	
Hollow	Texaco Star Grease No. 1
Solid	Texaco Electric Railway Compressor Oil (Summer or Winter)
SUBWAY FANS	Texaco Cetus or Nabob Oil
PLOW BARS	
Metallic System	Texaco Summer Black Oil and Winter Black Oil

TRACK DEPARTMENT

CURVES AND SWITCH POINTS	
Grease Lubricated	Texaco 904 Grease or Texaco Vega Grease No. 00
Oil Lubricated	Texaco Black Oils
AUTOMATIC SWITCHES	Texaco Hydra Oil
AUTOMATIC STOPS	Texaco Hydra Oil
RAIL GRINDERS	Texaco Electric Railway Compressor Oil (Summer or Winter)
PORTABLE AIR COMPRESSORS	Texaco Alcaid Oil

SIGNAL DEPARTMENT

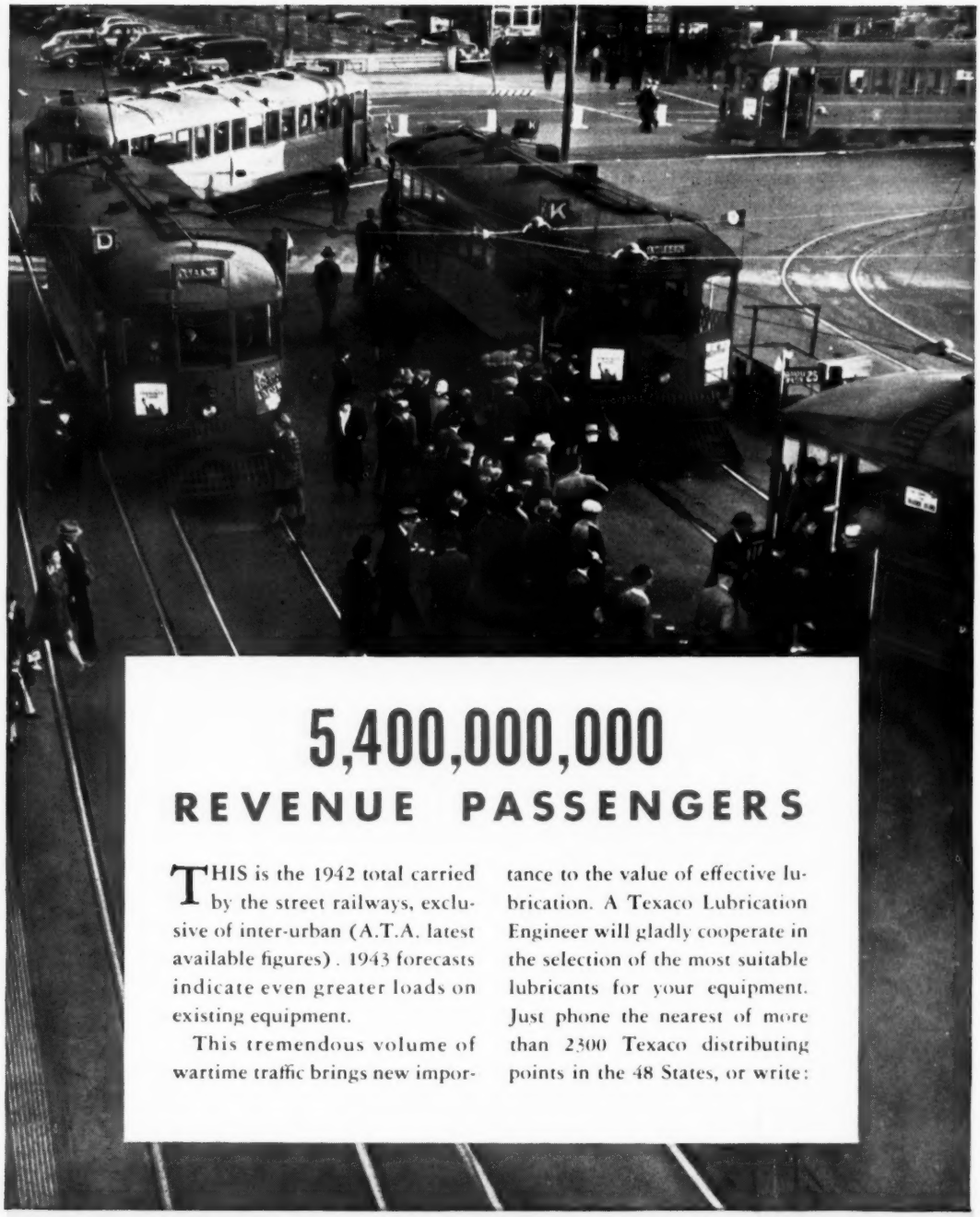
INTERLOCKING PARTS	Texaco Hydra Oil
AIR COMPRESSORS	Texaco Alcaid Oil
INTERLOCKING PLANT	
Cylinders	Texaco Star Grease No. 1
SHOP MACHINERY	
Oil Lubricated	Texaco Nabob or Aleph Oil
Grease Lubricated	Texaco Cup Greases
SWITCH MACHINERY	Texaco 542 Capella Oil

SHOP

SHOP COMPRESSORS	Texaco Alcaid Oil
MACHINE BEARINGS	Texaco Nabob or Aleph Oil
SHOP GEARS	Texaco Crater No. 1
WIRE CABLES	Texaco Crater A, No. 00 or No. 1
CUTTING, TURNING, BOLT CUTTING	Texaco Sultex Cutting Oils or Texaco Soluble Oils

SUB STATION

MOTOR GENERATOR BEARINGS	Texaco Regal Oils



5,400,000,000
REVENUE PASSENGERS

THIS is the 1942 total carried by the street railways, exclusive of inter-urban (A.T.A. latest available figures). 1943 forecasts indicate even greater loads on existing equipment.

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